



LHT
28,4

THEME ARTICLES

Utilizing geographic information systems (GIS) in library research

536

Received 3 June 2010
Revised 14 July 2010
Accepted 19 July 2010

Bradley Wade Bishop

*School of Library and Information Science, University of Kentucky, Lexington,
Kentucky, USA, and*

Lauren H. Mandel

Information Use Management & Policy Institute, Tallahassee, Florida, USA

Abstract

Purpose – The purpose of this research paper is to explore library research that uses geographic information systems (GIS) as a tool to measure and analyze library services and establish future directions for this research area.

Design/methodology/approach – This study reviews the library literature using GIS. The study searched full text for geographic information systems in two databases, Library Literature and Information Full Text and Library, Information Science and Technology Abstracts (LISTA). The titles and abstracts of the search results were analyzed to gather only the research that used GIS as a tool to measure and analyze library services.

Findings – This review of the literature reveals research using GIS as a tool in two ways: to analyze service area populations, including facility site location and other service and resource decision making; and to manage facilities, including in-library use and occupancy of library study space.

Practical implications – The findings are relevant for library and information science researchers and practitioners because they summarize a specific area of research that may be confusing for the novice, but beneficial to the field. Using GIS in practice and research could benefit library services by generating maps to convey more information than tables and text alone and by allowing spatial analysis of library services inside the library as well as in a library's service areas.

Originality/value – The paper provides future directions for an emerging research area and attempts to define subdivisions within this research area to clarify the area for researchers and practitioners.

Keywords Geographic information systems, Libraries, Library buildings, Library users, Information research, Service delivery

Paper type Literature review

Introduction

Eratosthenes, chief librarian of the museum in Alexandria from 234 to 192 BCE, coined the term "Geography" and made an early attempt at estimating the circumference of the Earth (Martin, 2005). With 2,000 plus years of advancement in technology since the first attempted measurement of the Earth, quantification and representation of the Earth have become more accurate and more frequent and researchers have created an inconceivable number of physical cartographic resources, such as Sanborn maps and aerial photogrammetry (Hill, 2006; Larsgaard, 1998; Martin, 2005). In addition to librarians acting as stewards of geospatial data, Library and Information Science (LIS) should reap the benefits of geospatial technologies to measure and analyze their own services – particularly Geographic Information Systems (GIS).



A recent quantitative literature review by Michalec and Welsh (2007) used search terms “geographic information systems (GIS)” and “geospatial” to find articles in *Library Literature and Information Full Text* and *LISTA Library, Information Science and Technology Abstracts* databases, to reveal 146 articles appeared in 69 different LIS publications from 1990-2005. Overall, the study found that the number of articles in LIS with the terms “geographic information systems (GIS)” or “geospatial” increased over that time. Although the study provided insight into the publication pattern of articles in LIS containing the terms GIS and geospatial, GIS retains a variety of meanings and uses. Therefore, a more thorough review of the literature requires examination beyond the quantity of articles that contain the term to include assessments of the content of these articles to understand better how GIS is being used and discussed in the LIS literature. The purpose of this paper is to explore the topics of library research that use GIS as a tool to measure and analyze library services and establish future directions for usage of GIS in LIS research.

Background

Allen (2001) conducted a review of GIS literature to determine the quantities of research in various disciplines to inform a library’s collection development policy for geospatial data. Allen (2001) searched for all articles with either “geographic information systems” or “GIS” in the title from 1995-2000 in *Current Contents/All Editions* and found that 2 percent of 875 total articles containing “geographic information systems” or “GIS” in the title came from the LIS discipline. Both the Allen (2001) and Michalec and Welsh (2007) reviews do not reveal anything of the content from the articles mentioning GIS in LIS. In contrast to these overviews, this study focuses on revealing the topics and foci of the library research that use GIS as a tool to measure and analyze library services, facilities, and use and on establishing future directions for applications of GIS to LIS research. Prior to beginning this literature review, a discussion on the meanings of GIS and the types of GIS-related work in LIS will assist to frame discussion of this paper’s methodology.

Tomlinson (1998), the leader of the first industry-scale computer-based GIS, known as the Canadian Geographic Information System, coined the term “geographic information systems” in the early 1960s to refer to any computer application that performed functions with geospatial data, that is, data related to space (Wade and Sommer, 2006). As more researchers used GIS as a tool, a variety of scientific questions, methods, and knowledge related to GIS developed. Goodchild (1992) proposed “Geographic Information Science” as a term that encompasses the scientific questions, methods, and knowledge that transcend the technology of any particular geographic information system. Waters’ (2003) “Geographic Information Systems” entry in the *Encyclopedia of Library and Information Science* discusses the various uses of the “GIS” acronym and points to the name change of the prominent journal *International Journal of Geographic Information Systems* to *International Journal of Geographic Information Science* in 1996 as a reflection of the trend in Geography away from the technology of GIS and toward the spatial statistics and other analyses emerging from the subdiscipline of Geographic Information Science.

These semantics of defining the meaning of the “GIS” acronym in geography are further complicated in LIS articles because LIS articles may focus on providing library services and resources to the variety of disciplines that utilize the technology, such as

geography, urban planning, and environmental science. The literature on GIS-related library services and resources (e.g. collection development, reference and research services, review of GIS technologies, and geospatial metadata) are relatively mature compared to literature on LIS research utilizing GIS as a tool to measure and analyze library services, facilities, and use; even a book has been written on implementing GIS services in libraries (Abresch *et al.*, 2008; Aufmuth, 2006; Donnelly, 2010; Houser, 2006; Jue, 1995; Kowal, 2002; Larsgaard, 2005; Smith and Gluck, 1995; Strasser, 1998). In academic library settings in particular, geographic information librarianship has emerged to facilitate the collection, dissemination, and use of geospatial data in addition to traditional print cartographic resources (Weimer and Reehling, 2006). In response to the growing demand for geographic information librarians, the Map and Geography Round Table (MAGERT) Education Committee (2008) developed core competencies for that type of information professional.

GIS offers other areas of research within LIS beyond geographic information librarianship or utilization of GIS as a tool to measure and analyze library services. Other LIS research related to GIS includes the societal context of geographic information (e.g. public access to government geospatial data, wayfinding and emergency response technologies, the geospatial web, and mapping availability of public Internet access) (Boxall, 2005; Jaeger *et al.*, 2007; Lake and Farley, 2007; Mandel *et al.*, 2010; Morville, 2005; Sawada *et al.*, 2006; Scharl and Tochtermann, 2005). As web-based mapping applications (e.g. GoogleMaps), Global Position Systems (GPS), and other geographic information systems become more commonplace, LIS research will continue to grapple with organizing and disseminating geospatial data, the societal context related to the increased access to geospatial data, and the greater numbers of users creating and using geographic information. However, the research areas related to geographic information librarianship and the societal context of GIS do not require GIS software expertise or the knowledge of cartographic and geographic principles necessary to produce valid and reliable spatial analyses and representations of data.

The purpose of this paper is to explore the type of LIS research that does require GIS software expertise and cartographic and geographic principles to conduct, which is, research in which data are analyzed and/or displayed spatially via GIS. As Xia (2004a) indicates, GIS requires a high level of expertise in computers and geography to utilize and uncover significant results. The authors speculate that this specialized geographic knowledge and expertise limits the quantity of LIS research utilizing GIS as a data analysis and display tool. However, Xia predicts the emergence of GIS utilization in LIS research because of its benefits, which include generating maps to convey more information than tables and text alone and allowing librarians to spatially analyze library services. In addition, GIS software has moved from a mainframe computer to a PC desktop setting to web-based applications, experienced reduction of overall costs and more open source options, and seen advances in usability of the systems, all of which will make the technology more accessible for librarians to use (Donnelly, 2010).

Methodology

This study reviewed the literature on the use of GIS with libraries. The study searched full text for geographic information systems in the two library-related databases

available at their institution, *Library Literature and Information Full Text* and *LISTA Library, Information Science and Technology Abstracts*. This wide net approach was used to ensure that any article related to utilizing GIS within these library databases would be captured. Other less frequently used derivations of GIS, such as geographical information systems, would also appear with a full text search of geographic information systems. The search results for geographic information systems included 207 records in *Library Literature and Information Full Text* and 810 records in *LISTA Library, Information Science and Technology Abstracts*. The discrepancy in number of records returned might be a result of *LISTA Library, Information Science and Technology Abstracts* indexing more than 200 other journals, including the aforementioned *International Journal of Geographic Information Systems*, now called the *International Journal of Geographic Information Science*.

The titles and abstracts of these results were analyzed to determine the content of the articles. Articles were marked that related to using GIS as a tool to measure and analyze library services, facilities, and use. Most of the records found with “Geographic Information Systems” did not match this categorization scheme. Most of the GIS articles retrieved discuss geographic information librarianship some other papers relate to the societal context of GIS, a couple of articles introduce GIS-enabled library programming and services, and several articles utilize GIS as a tool in other disciplines besides library services (i.e. the articles in the GIS journals indexed in *LISTA*). The following section discusses the findings from the data collection and provides a framework of the different types of studies conducted in LIS that use GIS as a tool to measure and analyze library services, facilities, and use data.

Findings

After the analysis of article titles and abstracts, 22 articles qualified from the search in *Library Literature and Information Full Text* and 32 qualified from the search in *LISTA Library, Information Science and Technology Abstracts* ($n = 54$). Two articles were unique to *Library Literature and Information Full Text*, 11 articles were unique to *LISTA Library, Information Science and Technology Abstracts*, and the other 20 were found in both databases. Overall, the search yielded 34 unique articles, which break down into the following two categories:

- (1) Analyzing service area populations (26).
- (2) Managing facilities and collections (eight).

Lists of references for these two categories are provided at the end of the paper for further reading beyond the brief discussion in this literature review. A few of these articles only include a discussion of what could be done with GIS in LIS. The articles that do utilize GIS and produce results often lack a thorough methods discussion. Therefore, the literature review does not discuss differences in spatial analyses used in the articles.

Analyzing service area populations

Any discussion of analyzing libraries' service area populations with GIS should begin with Koontz's (1997) *Library Facility Siting and Location Handbook*, but the book was not indexed in either *Library Literature and Information Full Text* or *LISTA Library, Information Science and Technology Abstracts*. Although the book did not appear in

this paper's search results, most of the 22 articles included in this section of the literature review cite this work. Two earlier articles with related research did appear in this paper's search results (Koontz, 1992, 1995). In Koontz's (1992, 1995) early work she explores the history of library location siting, facility location models, and the potential use of GIS for public library facility siting, which includes estimating and profiling service area populations.

GIS as a tool can be used to assist with these concerns, as well as other issues related to analyzing service area populations, which include decisions regarding opening and closing of branch locations and community outreach. Clark (1995) and Le Tourneau (2000) discuss similar potential for GIS in articles found in this paper's search results, without any analysis. Koontz continued work on projects that utilized GIS in various research areas, including optimal distribution of funding for low income and majority-minority communities and studying geographic market areas around public library closures (Jue *et al.*, 1999; Koontz *et al.*, 2009). With Koontz's efforts, Florida State University has become a center of research in this area, leading to the development of the national Public Library Geographic Database (PLGDB) (www.geolib.org). In another article from this paper's search results, Koontz and Jue (2004) provide an overview of the benefits of GIS for libraries and include instructions on how to use the PLGDB to analyze an individual library's or library system's geographic market area.

Five papers in the search results discuss the GIS services offered by Civic Technologies to map library users with demographic data to inform allocation of resources and services (Public Libraries, 2004; Advanced Technology Libraries, 2005; Dorman, 2002; Futterman, 2008; *D-Lib Magazine*, 2004). SirsiDynix offers similar services that allow libraries to allocate resources based on visualizations of their service areas with maps (Lee, 2007; Nesting, 2006). The Normative Data Project (NDP) utilizes GIS to predict circulation based on demographics and two of the articles found in this review discuss the potential of the tool for collection development (DeVoe, 2006; Molyneux, 2006).

Other studies from this paper's search results do not specify a vendor, but find GIS and especially its map-making capability useful in facility site decision-making. Analyzing patron data via GIS, Kinikin (2004) determines that another branch would be supported in an area of the county that has users, but no branch. Bishop (2008) uses a Euclidian allocation tool available in GIS to suggest geographic market areas based on allocation of each part of a county being assigned to its closest library branch, which reveals that some users need to travel much greater distances than others to reach a library branch.

Another study shows how librarians could use demographics to influence staffing and outreach, for example more Spanish-speaking staff and advertising in Spanish to meet the needs of a large Spanish-speaking population (Adkins and Sturges, 2004). Similarly, another study uses demographics of two new library locations to help plan the services and resources for them (Hertel and Sprague, 2007). Still another study uses geocoded users' addresses (i.e. latitude and longitude coordinates are assigned to the addresses to map them via GIS) to define library service areas. This facilitates determination that higher performing branches have more square footage, serve larger geographic areas, and, not surprisingly, are more heavily used (Preiser and Wang, 2006).

Utilization of GIS to analyze service area populations is also found in international research. Gaus *et al.* (2008) use GIS to analyze library branches that serve immigrants and to influence the library services at those library branches in Ghent, Belgium. Venuda (2005a, b) and Franqueville (2000) discuss the benefits of GIS as a marketing tool but do not have findings from a specific system to support the discussion, which is similar to some of the overview articles mentioned earlier.

So far, all the analyses of service area populations from this paper's literature review have involved mapping physical users of the library. However, one study also visualizes users that only virtually use library services by mapping IP (internet protocol) addresses of users that visit a statewide chat and e-mail reference consortium service (Mon *et al.*, 2009). Analyzing service area populations, both of physical and virtual library users, will continue to be an area for research growth, given its potential for helping libraries tailor services to better meet the needs of specific user populations.

Managing facilities

Within the facility, GIS can help librarians analyze any data relating to daily operations, such as collections management activities (Xia, 2004c) and other library utilization measures (Ottensmann, 1997). Ottensmann (1997) explains, "Geographic information systems (GIS) provide public libraries with the power to analyze patterns of library utilization in ways that have previously been impractical" (p. 24).

Much of the facilities management research found in this study is from Jingfeng Xia (2004a, b, c; 2005). Xia (2004b) reports several methods and uses he has made of GIS to map and better understand the use of academic library facilities and collections. In one study, he uses GIS as an automated space management system, something he explains academic libraries need as collections grow, shift, and become harder to manage. This project incorporates library floor plans with feature data (e.g. information about library bookshelves and call number ranges) to map and manage where collections are within the library in an automated way that does not require the manual observations and surveys on which Xia argues academic libraries tend to rely.

For other projects, Xia (2004c) has mapped the in-library use of materials, including investigating the impact of bookshelf height on in-library use of materials as well as the utility of GIS to determine if books on certain bookshelf ranges are used more frequently in the library than others Xia (2004a). In other work, Xia (2005) has brought GIS application beyond space management for the librarians into the hands of users by incorporating GIS with the code in a library OPAC to something he calls a GISils, or GIS item-location system. This allows the system to display a map of where a given book is located when the call number record is recalled, thus allowing the user to see not only the call number but also where that book is located physically within the library. The ultimate goal of this system is to facilitate user access to library collections.

Like Xia, Mandel applies GIS to in-library use research. In one paper, Mandel (2010a), introduces MapWindow, an open source GIS, as a free and easy-to-use tool for librarians and LIS researchers to use in analyzing and displaying data about where library users sit, read, congregate, and otherwise use the library facility. In another paper Mandel (2010b), uses GIS to analyze and spatially display the routes library users taken as they may find (i.e. orient and navigate) through the entry area of a public library facility.

Jones (1993) offers another use of GIS to evaluate library services, mapping circulation patterns. He explains that libraries need to visualize where their users live to understand the success of library services. This visualization can include mapping who borrows what materials based on their home address, calculating as a measure of library success the percentage of adults in a service area that are registered borrowers, and determining whether the distribution of users across a community is even.

Summary of findings

Overall, this paper finds that minimal research indexed in *Library Literature and Information Full Text* and *LISTA Library, Information Science and Technology Abstracts* databases represents utilizations of GIS as a tool to analyze and display library services, facilities, and use data. The LIS research that is utilizing GIS falls into two primary categories:

- (1) Analysis of library service populations and related adjustments to facilities and services based on user demographics and other variables.
- (2) Analysis of collections, in-library, and other facilities-based use.

One way to consider this categorization is that LIS research falling into the first category focuses primarily on variables outside the library, and LIS research falling into the second category focuses primarily on variables inside the library.

Limitations

The main limitation of this literature review is that the results are from two library literature databases, available at the institution of the authors, and only include the publications indexed within them. Untold numbers of consultation projects may have been conducted at local levels to assess library use and facility site location with GIS, but this paper only reviews the publications indexed in these databases. Using additional databases, inaccessible to these authors at their institution, such as *Library and Information Science Abstracts (LISA)* might have provided further articles that match the literature review's criteria. In addition, more consultation projects utilizing GIS may be findable when sought through search engines; however, this avenue was not explored for this literature review.

Future directions

The findings of this literature review and the experience of the authors indicate that there is a small, but growing emphasis on GIS in LIS research, as well as other areas of LIS such as geographic information librarianship, societal issues with geospatial data, etc. There is ample room for additional LIS research to utilize GIS as a valuable analysis and visualization tool. First of all, additional research can continue and expand on the two research areas found here, analyzing service area populations and managing facilities.

For example, much remains unknown or poorly understood about the issues, challenges, and impacts of libraries' unique service populations at the local level. Additionally, as library services increasingly occur in the virtual world, research can continue the work of Mon *et al.* (2009) in assessing the service area populations of virtual library services – both individual library's chat services and consortia providing virtual reference services.

With regard to managing facilities, even less research utilizing GIS seems to occur in this area than in analyzing service area populations, providing even more opportunities for future research agendas. In addition to more widespread adoption of and research regarding GIS as a collections and facilities management tool, research could utilize a combination of RFID (radio frequency identification) and GIS technologies to first track library users as they navigate a facility and then map their exact paths.

With the growth in the amount of research in the two research areas found in this review, perhaps best practices for methodology could be established. As mentioned previously, the majority of these articles provide the end result of analysis and the end products (i.e. maps) of their projects. However, without discussing specific methodological issues, strategies, and steps, duplication of the studies may be difficult and raises concerns over the validity and reliability of the reported data.

Second of all, there is a growing trend of libraries adopting GIS technologies for unique location-based services. Two articles excluded from the findings of this paper because they lack a research slant introduce two such applications of GIS-enabled technologies in library services and programs – geocaching and Foursquare (Funabiki, 2009; Porter and King, 2010). Foursquare is also featured in a recent *Library Journal* article emphasizing the value of location-based services in libraries (Rethlefsen, 2010). This trend offers research opportunities, such as investigations of information seeking behavior of library users participating in geocaching and Foursquare-style activities and evaluations of the effectiveness of marketing library services and resources with these technologies that may lead to increasing library use and/or user satisfaction with library services, among others.

In addition to these research areas, there is also room for research regarding implications of GIS for the LIS curriculum, both from the perspective of utilization of GIS in LIS research and the perspective of demand for trained geographic information librarians in the field. Also, the trend toward greater numbers of non-expert users of GIS has led to activities described as public participatory geographic information science (PPGIS). One example of PPGIS technologies is Community Response Grids that allow residents and professional emergency responders to work together in emergencies by sharing location information (Jaeger *et al.*, 2007). Usability and the implementation of these systems, web-based mapping applications, and other GIS are issues LIS researchers can explore further. The future directions presented here stem from past research as well as the findings of this literature review, but with only a handful of articles available that detail uses of GIS in LIS research, there is room to grow.

Conclusion

The purpose of this literature review was to explore LIS research that uses geographic information systems (GIS) as a tool to measure and analyze library services and to establish future directions for this research area. The study searched full text for geographic information systems in two databases and analyzed titles and abstracts to gather only the research that used GIS as a tool to measure and analyze library services. Review of the literature revealed research, using GIS as a tool to analyze service area populations, including facility site location and other service and resource decision-making, and to manage facilities, including in-library use and occupancy of

library study space. These two research areas used GIS in practice and research to benefit library services by generating maps and allowing spatial analysis of library services. With additional research in the area, perhaps more standardized methodology will emerge. GIS offers many areas of research for LIS. However, because GIS retains a variety of meanings and uses, this paper's and others' literature reviews of GIS in LIS should go beyond the acronym and explore the content of GIS publications.

References

- Abresch, J., Hanson, A., Heron, S.J. and Reehling, P.J. (2008), *Integrating Geographic Information Systems into Library Services: A Guide for Academic Libraries*, Information Science Pub., Hershey, PA.
- Adkins, D. and Sturges, D.K. (2004), "Library service planning with GIS and census data", *Public Libraries*, Vol. 43 No. 3, pp. 165-70.
- Advanced Technology Libraries (2005), "Civic Technologies announces new service", *Advanced Technology Libraries*, Vol. 34 No. 5, pp. 8-9.
- Allen, R.S. (2001), "Interdisciplinary research: a literature-based examination of disciplinary intersections using a common tool", *Geographic Information System (GIS), Science & Technology Libraries*, Vol. 21 Nos 3/4, pp. 191-209.
- Aufmuth, J. (2006), "Centralized vs distributed systems: academic library models for GIS and remote sensing activities on campus", *Library Trends*, Vol. 55 No. 2, pp. 340-8.
- Bishop, B.W. (2008), "Use of geographic information systems in marketing and facility site location", *Public Libraries*, Vol. 47 No. 5, pp. 65-9.
- Boxall, J. (2005), "The nature of geospatial information and security", *Government Information Quarterly*, Vol. 22 No. 4, pp. 644-62.
- Clark, P.M. (1995), "Thematic mapping, data mapping, and geocoding techniques for analyzing library and information center data", *Journal of Education for Library & Information Science*, Vol. 36 No. 4, pp. 330-41.
- D-Lib Magazine* (2004), "Glendale Public Library service area study successfully completed: Geographic Information Systems (GIS) application from Civic Technologies, Inc. provided key demographic data", *D-Lib Magazine*, Vol. 10 No. 5, p. 1.
- DeVoe, K. (2006), "Developing a predictive model of library collection use", *Against the Grain*, Vol. 18 No. 1, p. 63.
- Donnelly, F.P. (2010), "Evaluating open source GIS for libraries", *Library Hi Tech*, Vol. 28 No. 1, pp. 131-51.
- Dorman, D. (2002), "GIS provides a new way of seeing service areas", *American Libraries*, Vol. 33 No. 2, p. 62.
- Franqueville, P. (2000), "The new tools of urbanism at the service of prospective librarianship (English)", *Bulletin des Bibliothèques de France*, Vol. 45 No. 3, pp. 97-104.
- Funabiki, R. (2009), "Geocaching: hide and seek at your library", *Idaho Librarian*, Vol. 59 No. 2, pp. 1-2.
- Futterman, M. (2008), "Finding the underserved", *Library Journal*, Vol. 133 No. 17, pp. 42-5.
- Gaus, D., Velter, J. and Verhasselt, E. (2008), "Ook de plaats is een waarheid (Dutch/Flemish)", *Bibliotheek- en Archiefgids*, Vol. 84 No. 2, pp. 10-19.
- Goodchild, M.F. (1992), "Geographic information science", *International Journal of Geographical Information Systems*, Vol. 6 No. 1, pp. 31-45.

-
- Hertel, K. and Sprague, N. (2007), "GIS and census data: tools for library planning", *Library Hi Tech*, Vol. 25 No. 2, pp. 246-59.
- Hill, L. (2006), *Georeferencing*, MIT Press, London.
- Houser, B. (2006), "Building a library GIS service from the ground up", *Library Trends*, Vol. 55 No. 2, pp. 315-26.
- Jaeger, P.T., Shneiderman, B., Fleishmann, K.R., Preece, J., Qu, Y. and Wu, P.F. (2007), "Community response grids: e-government, social networks, and effective emergency management", *Telecommunications Policy*, Vol. 31, pp. 592-604.
- Jones, A.D. (1993), "Where do all the good books go? Geographic information systems and the local library", *Australian Library Journal*, Vol. 42, pp. 241-9.
- Jue, D.K. (1995), "Implementing GIS in the public library arena", *Geographic Information Systems and Libraries*, Graduate School of Library and Information Science, University of Illinois at Urbana-Champaign, Urbana-Champaign, IL, pp. 195-212.
- Jue, D.K., Koontz, C.M., Magpantay, J.N. and Lance, K.C. (1999), "Using public libraries to provide technology access for individuals in poverty: a nationwide analysis of library market areas using a geographic information system", *Library & Information Science Research*, Vol. 21 No. 3, pp. 299-325.
- Kinikin, J. (2004), "Applying geographic information systems to the Weber County Library System", *Information Technology & Libraries*, Vol. 23 No. 3, pp. 102-7.
- Koontz, C.M. (1992), "Public library site evaluation and location: past and present market-based modeling tools for the future", *Library & Information Science Research*, Vol. 14 No. 4, pp. 379-410.
- Koontz, C. (1995), "Using geographic information systems for estimating and profiling geographic library market areas", *Geographic Information Systems and Libraries*, Graduate School of Library and Information Science, University of Illinois at Urbana-Champaign, Urbana-Champaign, IL, pp. 181-93.
- Koontz, C.M. (1997), *Library Facility Siting and Location Handbook*, Greenwood Press, Westport, CT.
- Koontz, C. and Jue, D.K. (2004), "Customer data 24/7 aids library planning and decision making", *Florida Libraries*, Vol. 47 No. 1, pp. 17-19.
- Koontz, C.M., Jue, D.K. and Bishop, B.W. (2009), "Public library facility closure: an investigation of reasons for closure and effects on geographic market areas", *Library & Information Science Research*, Vol. 31 No. 2, pp. 84-91.
- Kowal, K. (2002), "Tapping the web for GIS and mapping technologies: for all levels of libraries and users", *Information Technology and Libraries*, Vol. 21 No. 3, pp. 109-14.
- Lake, R. and Farley, J. (2007), "Infrastructure for the geospatial web", in Scharl, A. and Tochtermann, K. (Eds), *The Geospatial Web: How Geobrowsers, Social Software, and the Web 2.0 Are Shaping the Network Society*, Springer-Verlag, London, pp. 15-26.
- Larsgaard, M.L. (1998), *Map Librarianship: An Introduction*, Libraries Unlimited, Englewood, CO.
- Larsgaard, M.L. (2005), "Metaloging of digital geospatial data", *Cartographic Journal*, Vol. 42 No. 3, pp. 231-7.
- Le Tourneau, C. (2000), "Putting a geographical information system to work in the context of a regional library (English)", *Bulletin des Bibliothèques de France*, Vol. 45 No. 6, pp. 77-81.
- Lee, S. (2007), "Mapping service areas at the Huntsville-Madison County Public Library", *Public Library Quarterly*, Vol. 26 No. 1, p. 117.

- Mandel, L.H. (2010a), "Geographic information systems: tools for displaying in-library use data", *Information Technology & Libraries*, Vol. 29 No. 1, pp. 47-52.
- Mandel, L.H. (2010b), "Toward an understanding of library patron wayfinding: observing patrons' entry routes in a public library", *Library & Information Science Research*, Vol. 32 No. 2, pp. 116-30.
- Mandel, L.H., Bishop, B.W., McClure, C.R., Bertot, J.C. and Jaeger, P.T. (2010), "Broadband for public libraries: importance, issues, and research needs", *Government Information Quarterly*, in press.
- Map and Geography Round Table Education Committee (2008), *Map, GIS and Cataloging/Metadata Librarian Core Competencies*, American Library Association, Chicago, IL.
- Martin, G.J. (2005), *All Possible Worlds: A History of Geographical Ideas*, Oxford University Press, New York, NY.
- Michalec, M. and Welsh, T.S. (2007), "Quantity and authorship of GIS articles in library and information science literature, 1990-2005", *Science & Technology Libraries*, Vol. 27 No. 3, pp. 65-77.
- Molyneux, B. (2006), "Predicting high-circulating titles for public libraries", *Against the Grain*, Vol. 18 No. 3, pp. 92-3.
- Mon, L., Bishop, B.W., McClure, C.R., McGilvray, J., Most, L., Milas, T.P. and Snead, J.T. (2009), "The geography of virtual questioning", *Library Quarterly*, Vol. 79 No. 4, pp. 393-420.
- Morville, P. (2005), *Ambient Findability*, O'Reilly, Sebastopol, CA.
- Nesting, V. (2006), "SirsiDynix creates public library demographic market analysis tool", *Public Libraries*, Vol. 45 No. 3, p. 70.
- Ottensmann, J.R. (1997), "Using geographic information systems to analyze library utilization", *Library Quarterly*, Vol. 67 No. 1, pp. 24-49.
- Porter, M. and King, D.L. (2010), "Foursquare for libraries", *Public Libraries*, Vol. 49 No. 2, pp. 22-4.
- Preisner, W.F.E. and Wang, X. (2006), "Assessing library performance with GIS and building evaluation methods", *New Library World*, Vol. 107 No. 5, pp. 193-217.
- Public Libraries (2004), "Civic Technologies announces new library decision maps on demand GIS service for smaller public libraries", *Public Libraries*, Vol. 43 No. 6, p. 365.
- Rethlefsen, M.L. (2010), "Checking in: location services for libraries", *Library Journal*, Vol. 135 No. 8, pp. 42-3.
- Sawada, M., Cossette, D., Wellar, B. and Kurt, T. (2006), "Analysis of the urban/rural broadband divide in Canada: using GIS in planning terrestrial wireless deployment", *Government Information Quarterly*, Vol. 23 No. 3, pp. 454-79.
- Scharl, A. and Tochtermann, K. (2005), *The Geospatial Web: How Geobrowsers, Social Software and the Web 2.0 Are Shaping the Network Society*, Springer, London.
- Smith, L.C. and Gluck, M. (1995), "Geographic Information Systems and libraries: patrons, maps, and spatial information", *Clinic on Library Applications of Data Processing*, Graduate School of Library and Information Science, University of Illinois at Urbana-Champaign, Urbana-Champaign, IL.
- Strasser, T.C. (1998), "Geographic information systems and the New York State Library: mapping new pathways for library service", *Library Hi Tech Journal*, Vol. 16 No. 3, pp. 43-50.

-
- Tomlinson, R. (1998), "The Canada Geographic Information System", in Foresman, T.W. (Ed.), *The History of Geographic Information Systems: Perspectives from the Pioneers*, Prentice-Hall, Upper Saddle River, NJ, pp. 21-32.
- Venuda, F. (2005a), "GIS (Geographic Information System) in biblioteca: prima parte" (in English), *Bollettino AIB*, Vol. 45 No. 3, pp. 327-45.
- Venuda, F. (2005b), "GIS (Geographic Information System) in biblioteca (Seconda parte)", *Bollettino AIB*, Vol. 45 No. 4, pp. 477-88.
- Wade, T. and Sommer, S. (2006), *A to Z GIS: An Illustrated Dictionary of Geographic Information Systems*, ESRI Press, Redlands, CA.
- Waters, N. (2003), *Geographic Information Systems, Encyclopedia of Library and Information Science*, Taylor & Francis, London, pp. 1106-14.
- Weimer, K.H. and Reehling, P. (2006), "A new model of geographic information librarianship: description, curriculum, and program proposal", *Journal of Education for Library and Information Science*, Vol. 47 No. 4, pp. 291-302.
- Xia, J. (2004a), "GIS in the management of library pick-up books", *Library Hi Tech*, Vol. 22 No. 2, pp. 209-16.
- Xia, J. (2004b), "Library space management: a GIS proposal", *Library Hi Tech*, Vol. 22 No. 4, pp. 375-82.
- Xia, J. (2004c), "Using GIS to measure in-library book-use behavior", *Information Technology & Libraries*, Vol. 23 No. 4, pp. 184-91.
- Xia, J. (2005), "Locating library items by GIS technology", *Collection Management*, Vol. 30 No. 1, pp. 63-72.

About the authors

Bradley Wade Bishop is an Assistant Professor in the School of Library and Information Science at the University of Kentucky. His research interests include Digital Reference and Geographic Information Studies. His BS in Marketing is from the University of Florida, his MA in LIS from the University of South Florida, and his PhD from the College of Communication and Information at the Florida State University. Bradley Wade Bishop is the corresponding author and can be contacted at: bradleywadebishop@gmail.com

Lauren H. Mandel is a Doctoral Candidate at FSU's College of Communication and Information and Research Coordinator at the Information Institute (www.ii.fsu.edu/). Her research interests include Public Library Facility Design, Wayfinding, and Geographic Information Studies. Her BA is from Vassar College and her MS in LIS is from Simmons College.